Design Guide: TIDA-010250
1kW BLDC Motor Inverter Reference Design

Description

This reference design illustrates a motor inverter with MSPM0G1507, an Arm® Cortex®-M0+ core microcontroller. The design not only supports a sensorless Field Orientation Control (FOC) algorithm with 1–3 shunt resistors, but also a sensored motor driving algorithm with a Hall-effect Sensor or Quadrature Encoder Interface (QEI) sensor. The hardware and software available with this reference design are tested and ready-to-use to help accelerate development time to market.

Resources

TIDA-010250	Design Folder
MSPM0G1507	Product Folder
UCC28881	Product Folder
UCC27712	Product Folder
TLV9064	Product Folder
TPS54202	Product Folder
ISO6721	Product Folder

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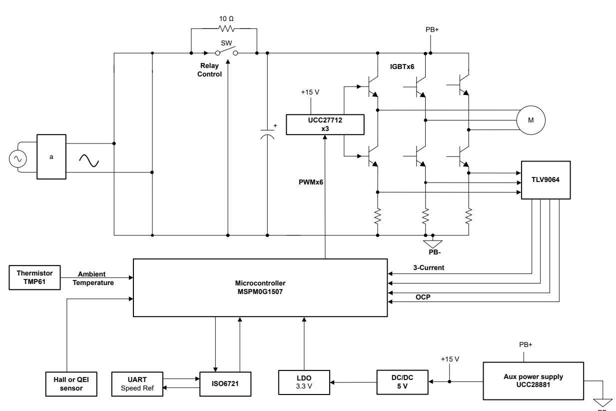
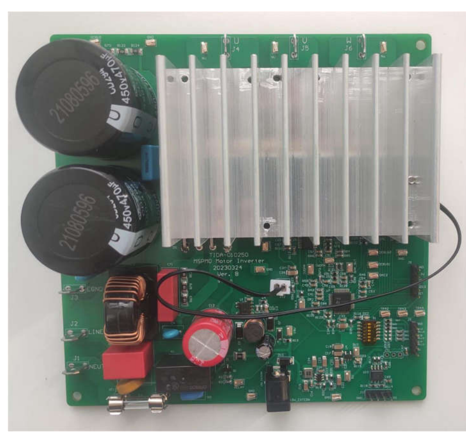
Features

- Sensorless FOC algorithm motor control with 1, 2, or 3 shunt resistors
- Sensored motor control with Hall-effect or QEI
- Up to 1kW inverter stage
- Robust design with overcurrent and overvoltage protections

Applications

- Refrigerator and freezer
- Washer and dryer
- Mixer, blender, and food processor
- Cooker hood
- Air conditioner indoor unit





1 System Description

Today's motor control for major appliance applications must meet a growing list of demands on lower cost, smaller size, more power and higher energy efficiency. Brushless Direct Current (BLDC) motor and Permanent Magnet Synchronous Motor (PMSM) is becoming increasingly popular in major appliance applications. With the help of high-speed Arm Cortex-M0+ core and rich analog peripherals, the MSPM0G1507 microcontroller provides a true single-chip solution for sensored or sensorless motor control, which helps designers to reduce the number of components in the bill of materials and to design a compact, cost-effective motor inverter.

1.1 Key System Specifications

PARAMETERS	TEST CONDITION	MIN	NOM	MAX	UNIT
Input Voltage		165	230	265	VAC
Input Frequency		47	50	63	HZ
PWM Switching Frequency (f_{SW})			8		kHz
Rated Power Output (P_{OUT})			1		kW
Output Current (I_{RMS})			3		A
Inverter Efficiency			97		%
Motor Electrical Frequency		30	100	200	Hz
Fault Protections	Overcurrent, overvoltage, overtemperature, undervoltage				
Drive Control Method	Sensored motor control with Hall-effect or QEI; Sensorless motor control with 1, 2, or 3 shunt resistors				
Operating Ambient	Open Frame	–10	25	55	°C
Built-in Auxiliary Power Supply	V_{INAC} = MIN to MAX	15V ±10%, 200mA			
Board Size	140mm × 140mm × 40mm				

WARNING

TI intends this reference design to be operated in a lab environment only and does not consider the reference design to be a finished product for general consumer use.

TI Intends this reference design to be used only by qualified engineers and technicians familiar with risks associated with handling high-voltage electrical and mechanical components, systems, and subsystems.

High voltage! There are accessible high voltages present on the board. The board operates at voltages and currents that can cause shock, fire, or injury if not properly handled or applied. Use the equipment with necessary caution and appropriate safeguards to avoid injuring yourself or damaging property.

Hot surface! Contact can cause burns. **Do not touch!** Some components can reach high temperatures > 55°C when the board is powered on. The user must not touch the board at any point during operation or immediately after operating, as high temperatures can be present.

CAUTION

Do not leave the design powered when unattended.

2 System Overview

2.1 Block Diagram

Figure 2-1 shows the reference design block diagram.

The entire system is represented in the following blocks:

- Auxiliary power supply
- MCU controller
- 3-phase inverter
- Phase current sensing with shunt resistors
- Hall-effect or QEI interface
- Isolated universal synchronous or asynchronous, receiver or transmitter (USART) serial communication

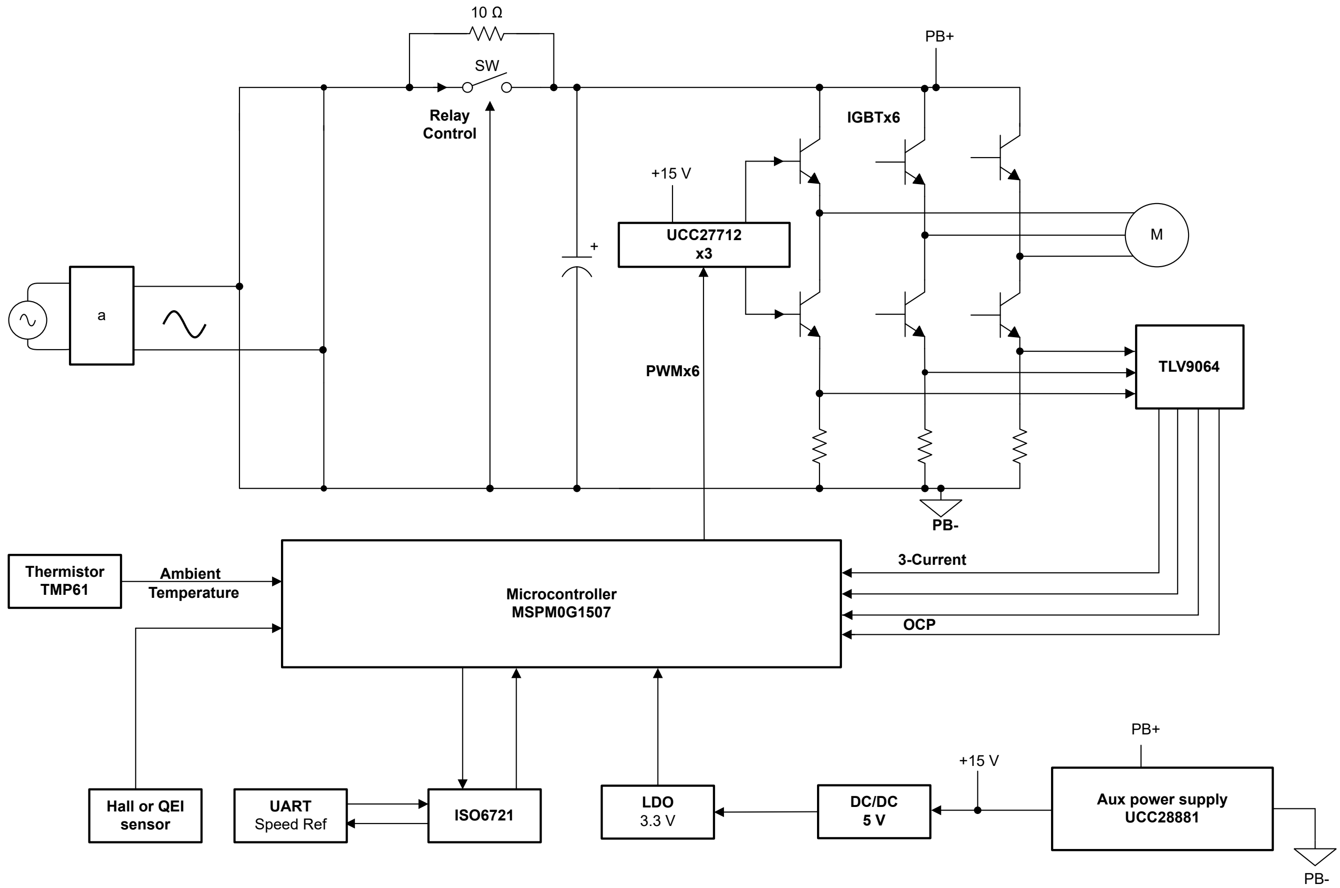


Figure 2-1. Block Diagram of the Reference Design

2.2 Design Considerations

This system starts from a diode bridge with electrolytic capacitors to create a stable DC bus. A simple UCC28881-based high-voltage buck supply provides non-isolated 15V to the gate driver UCC27712 to drive insulated-gate bipolar transistors (IGBT).

The TPS54202 DC/DC controller steps down 15V to 5V, and the TLV74033 provides a low-ripple 3.3V to power on the microcontroller as well as to be a voltage reference for an analog-to-digital converter (ADC).

The MSPM0G1507 microcontroller delivers six PWMs to gate drivers for IGBTs to control the current flow to the motor, the device also senses the DC bus voltage, ambient temperature, Hall-effect or QEI signals, and phase currents to implement the motor control algorithm.

2.3 Highlighted Products

The following highlighted products are used in this reference design. Key features for selecting the devices for use in this reference design are revealed in the following sections. Find more details of the highlighted devices in the respective product data sheet.

2.3.1 MSPM0G1507

The MSPM0G1507 microcontrollers (MCUs) are part of the highly-integrated, ultra-low-power, 32-bit MCU family from mixed-signal processing (MSP) based on the enhanced Arm® Cortex®-M0+ 32-bit core platform operating at up to 80MHz frequency. These cost-optimized MCUs offer high-performance analog peripheral integration, support extended temperature ranges from –40°C to 125°C, and operate with supply voltages ranging from 1.62V to 3.6V. The MSPM0G1507 devices provide up to 128KB embedded Flash program memory with built-in error correction code (ECC) and up to 32KB SRAM with hardware parity option. The devices also incorporate a memory protection unit, seven-channel DMA, math accelerator, and a variety of high-performance analog peripherals such as two 12-bit 4-MSPS ADCs, configurable internal shared voltage reference, one 12-bit 1MSPS DAC, three high-speed comparators with built-in reference digital-to-analog converters (DACs), two zero-drift, zero-crossover op amps with programmable gain, and one general-purpose amplifier. These devices also offer intelligent digital peripherals such as three 16-bit advanced control timers, three 16-bit general purpose timers, one 24-bit high-resolution timer, two windowed-watchdog timers, and one RTC with alarm and calendar mode. These devices provide data integrity and encryption peripherals and enhanced communication interfaces (four UARTs, two I2Cs, two serial-peripheral interfaces (SPIs)).

2.3.2 UCC28881

The UCC28881 integrates the controller and a 14Ω, 700V power MOSFET into one monolithic device. The device also integrates a high-voltage current source, enabling start-up and operation directly from the rectified mains voltage. The UCC28881 is the same family device of the UCC28880, with higher current.

The low quiescent current of the device enables excellent efficiency. With the UCC28881, the most common converter topologies, such as buck, buck- boost, and flyback can be built using a minimum number of external components.

2.3.3 UCC27712

The UCC27712 is a 620V, high-side and low-side gate driver with 1.8A source, 2.8A sink current, targeted to drive power MOSFETs or IGBTs. The recommended VDD operating voltage is 10V to 20V for IGBTs and 10V to 17V for power MOSFETs. The UCC27712 includes protection features where the outputs are held low when the inputs are left open or when the minimum input pulse width specification is not met. Interlock and dead-time functions prevent both outputs from being turned on simultaneously.

2.3.4 TLV9064

The TLV9064 is a quad-low-voltage (1.8V to 5.5V) op amp with rail-to-rail input- and output-swing capabilities. These devices are highly cost-effective designs for applications where low-voltage operation, a small footprint, and high capacitive load drive are required. Although the capacitive load drive of the TLV906x is 100pF, the resistive open-loop output impedance makes stabilizing with higher capacitive loads simpler. The TLV906xS devices include a shutdown mode that allow the amplifiers to switch into standby mode with typical current consumption less than 1µA. The TLV906xS family helps simplify system design, because the family is unity-gain stable, integrates the RFI and EMI rejection filter, and provides no phase reversal in the overdrive condition.

2.3.5 TPS54202

The TPS54202 is a 4.5V to 28V input voltage range, 2A synchronous buck converter. The device includes two integrated switching FETs, internal loop compensation and 5ms internal soft start to reduce component count.

Advanced Eco-mode implementation maximizes the light load efficiency and reduces the power loss.

Cycle-by-cycle current limit in both high-side MOSFETs protects the converter in an overload condition and is enhanced by a low-side MOSFET freewheeling current limit which prevents current runaway.

3 System Design Theory

The main focus of this reference design is a motor control system with a MSPM0G1507 microcontroller to support both sensored and sensorless FOC algorithms for appliance applications.

3.1 High-Voltage Buck Auxiliary Power Supply

A simplified UCC28881-based high-voltage buck supply provides an auxiliary power supply for this reference design to delivery up to 200mA for 15VDC.

Figure 3-1 shows the UCC28881 high-voltage buck supply circuit.

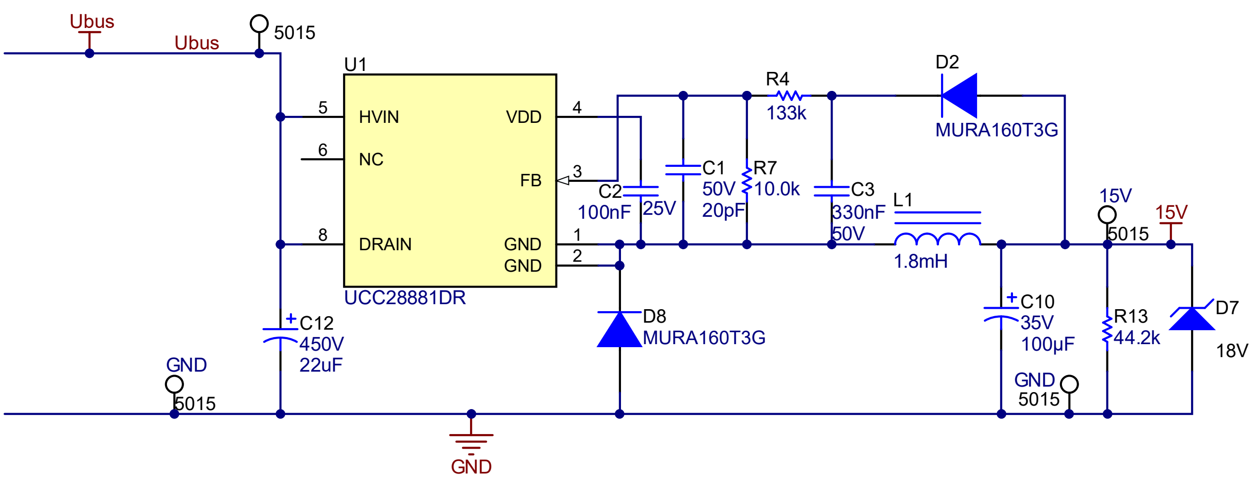


Figure 3-1. UCC28881 High-Voltage Buck Supply Circuit

3.2 DC Bus Voltage Sensing

The DC voltage sensing circuit is used to convert the rectified voltage signal into a low-voltage signal, a low-cost resistor divider network as shown in Figure 3-2. The DC bus voltage can also be used to estimate AC input voltage.

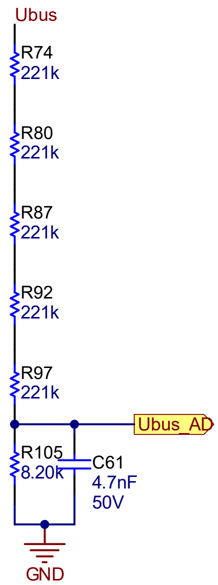


Figure 3-2. DC Bus Sensing Circuit

3.3 Motor Drive Stage

The three-phase motor inverter is realized with a six piece, 10A IGBT. Figure 3-3 shows a one-half bridge IGBT and the driver circuit. The IGBT gate resistor can be changed to control IGBT rising or falling time to make a tradeoff between power loss and EMI noise level.

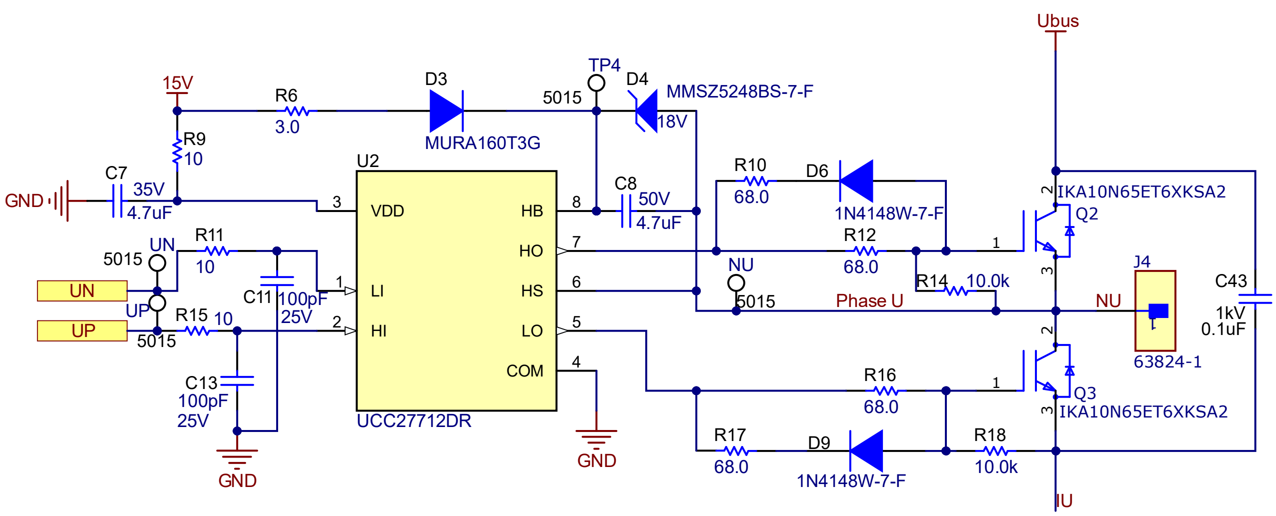


Figure 3-3. Half-Bridge IGBTs and Gate Driver

3.4 Bypass Capacitors

Each half-bridge has a high-voltage (1kV) ceramic bypass capacitor (C43, C48, and C62 on the schematic) providing a capacitance of 0.1µF per half-bridge, see Figure 3-3. These bypass capacitors handle high-frequency current in each half-bridge during switching, which cannot be provided by electrolytic DC bulk capacitors. Those X7R capacitors can also help to reduce EMI noise level.

3.5 Phase Current Sensing With Two or Three Shunt Resistors

This reference design supports 1, 2, or 3 shunt resistors. Three phase currents are sensed by an external TLV9064 in this reference design; however, the MSPM0G1507 microcontroller has two built-in zero-drift, zero-crossover operational amplifiers. These op amps support up to 2 phases of current sampling, so external op amps are not necessary, thus reducing the cost for the system. Figure 3-4 shows the shunt resistor configuration.

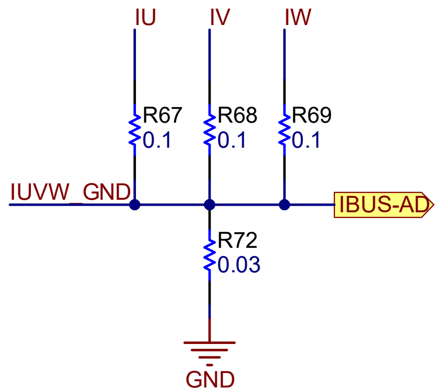


Figure 3-4. Shunt Resistor Configuration

3.6 Phase Current Sensing With a Single Shunt Resistor

This reference design also supports single-phase current sensing with a built-in op amp. R72 in Figure 3-4 is the shunt resistor for single-phase current sensing, R67, R68, and R69 can be shorted for such an application. The internal op amp OPA0 is selected to support single-phase current sensing. Figure 3-5 shows the circuit for internal OPA0, gain, and bandwidth can be set by those resistors and capacitors, the default gain is 2.

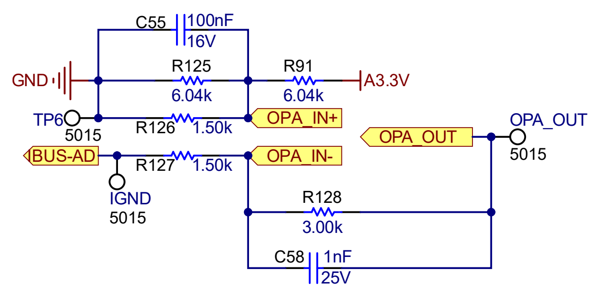


Figure 3-5. Circuit for Internal Op Amp OPA0

3.7 Hall-Effect Sensor or QEI Interface for Sensored Motor Control

This reference design also supports Hall or Quadrature Encoder Interface (QEI) mode-based sensored motor control algorithms. The MSPM0G1507 has a TIMG timer which supports 2- or 3-signal QEI. When configured in QEI mode, TIMG can collect the quadrature encoded signals to provide the information on the relative positioning and movement of a linear or rotary motion.

The QEI consists of two gray coded quadrature input signals PHA and PHB, and an index input signal IDX. All input signals go to the CCP inputs of a single counter, such that PHA and PHB are mapped to CCP0 and CCP1, and IDX is brought in as a separate input.

This reference design supports both a 3.3V or 5V level Hall-effect sensor for the following:

- Use the 3.3V Hall-effect or QEI sensor
- Switch on all Hall1V33, Hall2V33, Hall3V33

- Depopulate R64, R65, and R66
- Use the 5V Hall-effect or QEI sensor
- Switch off all Hall1V33, Hall2V33, Hall3V33, QEI1GND, QEI2GND, and QEI3GND of switcher S1
- Populate R64, R65, and R66

Figure 3-6 shows the Hall and QEI interface circuit

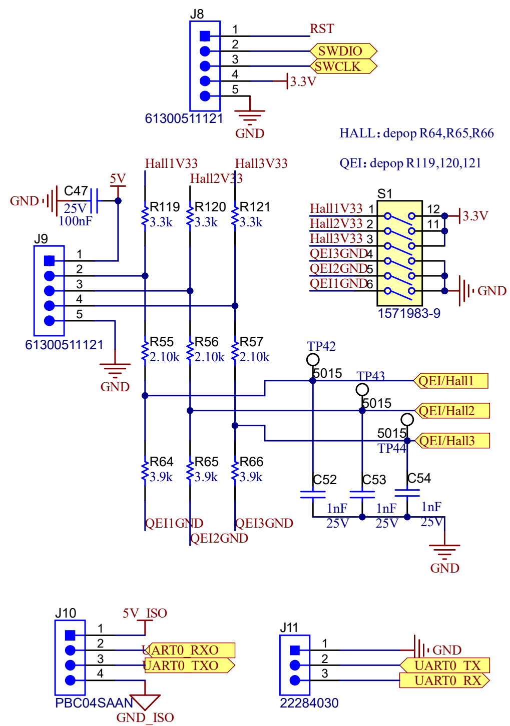


Figure 3-6. Hall and QEI Interface Circuit

3.8 DAC for Software Debug

To simplify software debugging, this reference design provides two DACs to export specified signals, such as rotator angle, simplified phase current, PWM duty, and so forth. As represented in Figure 3-7, DAC is an independent, internal, 12-bit digital-to-analog converter. DAC2 in Figure 3-7 is an indirect 8-bit digital to analog converter, which must be buffered through the internal op amp - OPA0. However; if OPA0 is used for phase current sensing, the op amp cannot output DAC2. Figure 3-7 shows the digital-to-analog converter circuit.

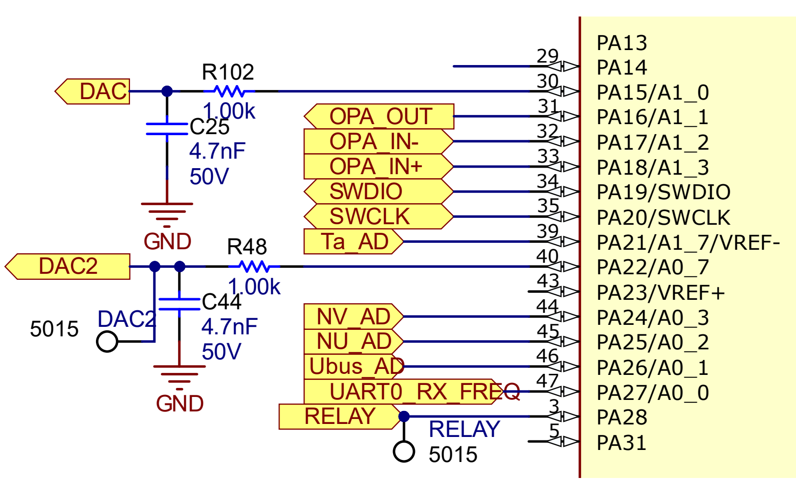


Figure 3-7. Digital-to-Analog Converter

3.9 Overcurrent Protection

This reference design implements overcurrent protection (OCP) with both external op amps and an internal comparator. Figure 3-8 shows the external op amp OCP, this circuit summarize three phases of current, then compares to a reference voltage (0.2V) to create an overcurrent fault signal. The other OCP is an internal comparator for a single shunt resistor current sensing. Internal op amp output can be connected directly to an internal comparator, to accomplish overcurrent protection. The designed external op amp OCP trigger point is 6A peak phase current, while the OCP trigger point for the internal comparator can be set by the internal reference.

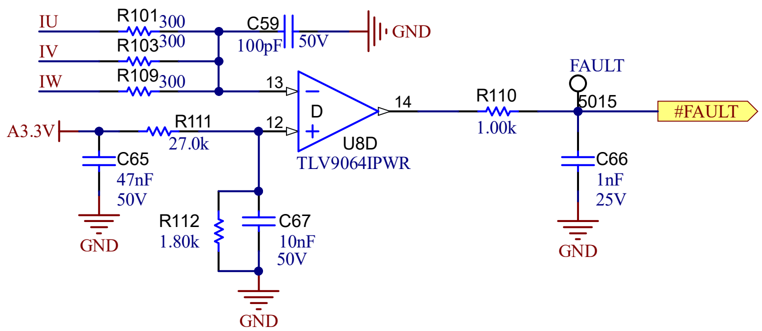


Figure 3-8. External Overcurrent Protection Circuit

3.10 Overtemperature Protection

An M3 screw mounting hole is designed to attach a thermistor on the heat sink to sense heat sink temperature. Software can sample this temperature signal to trigger overtemperature protection at a specified level.

3.11 Isolated UART port

An isolated UART port is provided to communicate with the host controller at J10. An external 5V or 3.3V rail is needed to power the isolated side of the U10 isolator.

3.12 Inverter Peak Power Capability

This reference design uses a 10A IGBT, which can deliver a continuous current of up to $6A_{RMS}$ at a junction temperature of 125°C. The $6A_{RMS}$ is an intermittent maximum current rating for the TIDA-010250 design. The continuous current capability of the inverter (which is ≤ 6 A_{RMS}) is determined by the thermal design. The peak power capability (P_{PEAK}) of the GaN inverter, assuming a 3-phase output voltage (V_{OUT}) of $200V_{RMS}$ and unity power factor (PF) is given by Equation 1:

$$P_{PEAK} = \sqrt{3} \times V_{OUT} \times I_{OUT} \times PF = \sqrt{3} \times 200 \times 6 \times 1 = 2078\ W \quad (1)$$

P_{PEAK} is the absolute maximum power the GaN inverter can handle - the continuous power rating of the inverter is decided by thermal design, peak ambient temperature, and overcurrent protection setting.

4 Hardware, Software, Testing Requirements, and Test Results

4.1 Hardware Requirements

This section details the necessary equipment, test setup, and procedure instructions for the design board and software testing and validation.

4.1.1 Hardware Board Overview

Figure 4-1 shows a system block diagram of this reference design.

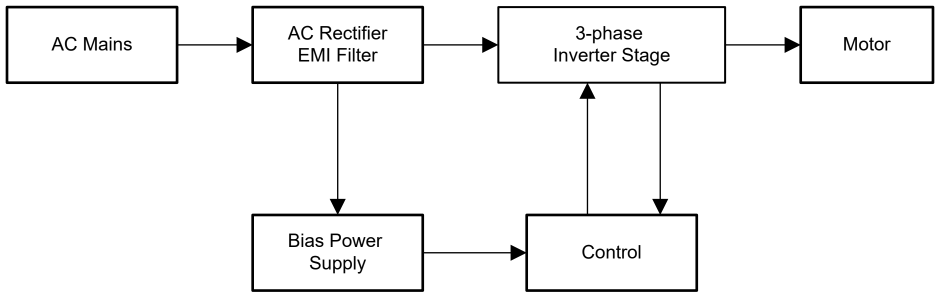


Figure 4-1. TIDA-010250 System Block Diagram

The motor control board has functional groups that enable a complete motor drive system. The following is a list of the blocks on the board and the functions of the blocks. Figure 4-2 shows the top view of the board and different blocks of the TIDA-010250 PCB.

- AC input connectors and filter
- Auxiliary power supply
- MCU controller
- Motor inverter output connector
- Phase current sensing with shunt resistors
- Hall or QEI interface
- USART serial communication

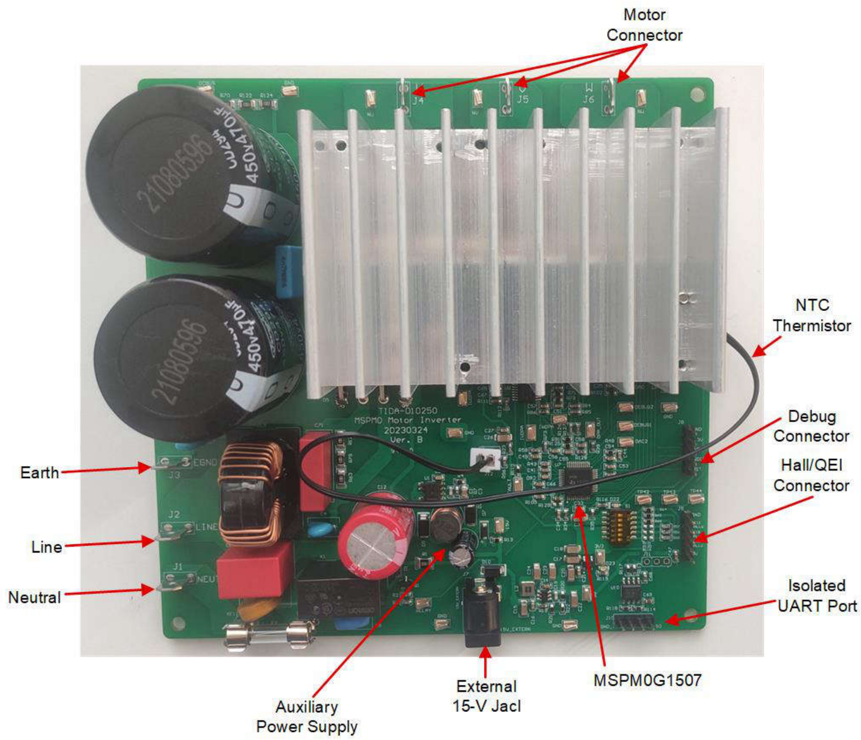


Figure 4-2. Layout of M0 Motor Inverter Board

TI recommends taking the following precautions when using the board:

- Do not touch any part of the board or components connected to the board when the board is energized.
- Use the AC Mains or wall power supply to power the kit. TI recommends an isolation AC source.
- Do not touch any part of the board, the kit, or the assembly when energized. Though the power module heat sink is isolated from the board, high-voltage switching generates some capacitive coupled voltages over the heat sink body.
- Control Ground can be hot.

4.1.2 Test Equipment for Board Validation

The following equipment is recommended for board validation:

- Isolated AC source
- Single-phase power analyzer
- Digital oscilloscope
- Multimeters
- Three-phase PMSM motor
- Dynamo meters
- DC current source with up to 6A current
- $15V_{DC}$ power supply preferred
- Three-phase power analyzer

4.2 Software Requirements

4.2.1 Getting Started MSPM0 Firmware

Download and install MSPM0-SDK `mspm0_sdk_2_01_00_03` or newer software from the link provided by TI. Install this MSPM0 SDK software in the default folder. The TIDA010250 software project then resides inside the MSPM0 SDK folder at `<install_location>\ti\mspm0_sdk_2_01_00_03\examples\nortos\LP_MSPM0G3507\motor_control_bldc_sensorless_foc\senslroess-foc_TIDA010250\`

4.2.1.1 Download and Install Software Required for Board Test

1. Download and install MSPM0-SDK, `mspm0_sdk_2_01_00_03` or newer software from the link provided by TI.
2. Install MSPM0-SDK in one of two ways:
   - Go to CCS, under *Project → Import CCS Project*, browse to choose the `senslroess-foc_TIDA010250` folder to import this project.
   - Go to CCS and under *View → Resource Explorer*. Under the *TI Resource Explorer*, go to *Arm-based microcontroller → Embedded Software → MSPM0-SDK*, and click *Download* and *Install*.
3. Once installation is complete, close CCS, and create a new workspace for importing the project

4.2.1.2 Import the Project Into CCS

Open CCS, and select *Project → Import CCS Project*, browse to following folder in MSPM0 SDK:

`<install_location>\ti\mspm0_sdk_2_01_00_03\examples\nortos\LP_MSPM0G3507\motor_control_bldc_sensorless_foc\sensorless-foc_TIDA010250`, Figure 4-3 shows the folder.

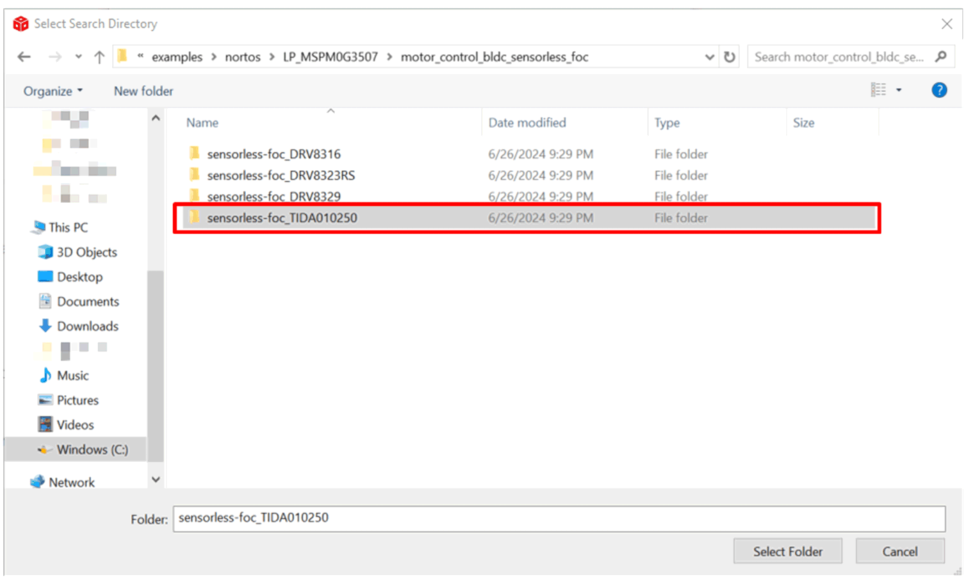


Figure 4-3. Folder of sensorless-foc_TIDA010250

[Figure 4-4](#) shows the project found in this folder. Select the project and click the *Finish* button to import this project.

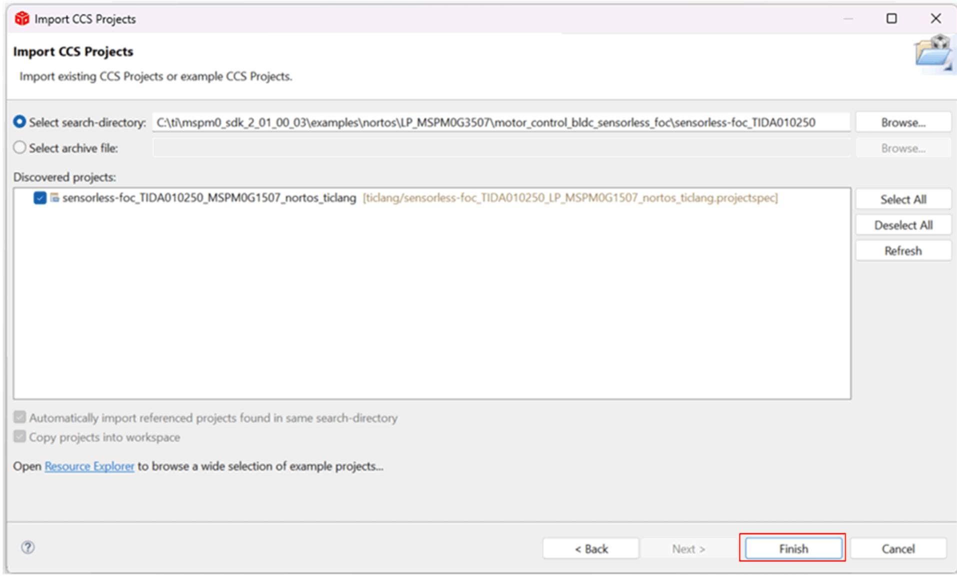


Figure 4-4. Project in This Folder

4.2.1.3 Compile the Project

The `sensorless-foc` project for TIDA-010250 is now active. Click the *Build* button or select the *Project* → *Build Project* menu, the `.out` file is now generated after the compilation is finished. [Figure 4-5](#) shows the resulting project build.

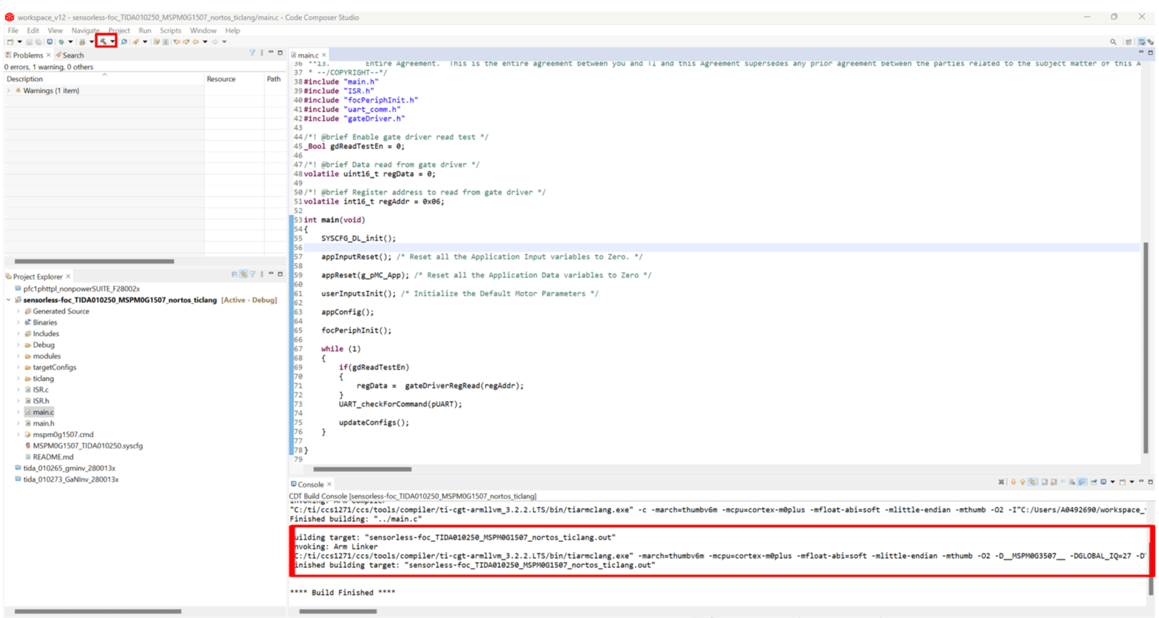


Figure 4-5. Build Project

Now open the `ISR.c` file to check motor parameters, see the register map section in the *Sensorless FOC Motor Control User Guide*, this guide is found in the MSPM0 SDK folder:

`<install_location>\ti\mspm0_sdk_2_01_00_03\docs\english\middleware\motor_control_bldc_sensorless_foc`

Figure 4-6 shows file location.

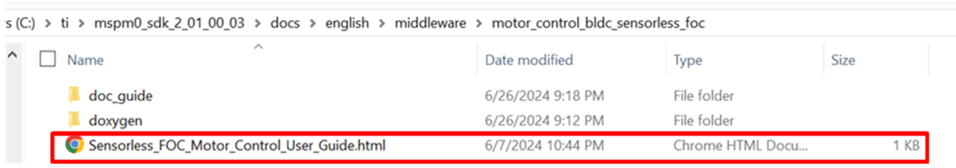


Figure 4-6. Folder for Sensorless FOC Motor Control User Guide

This design guide introduces all the registers for the FOC algorithm, the designer can also add or remove some special functions of FOC using those registers. Figure 4-7 shows the register map.

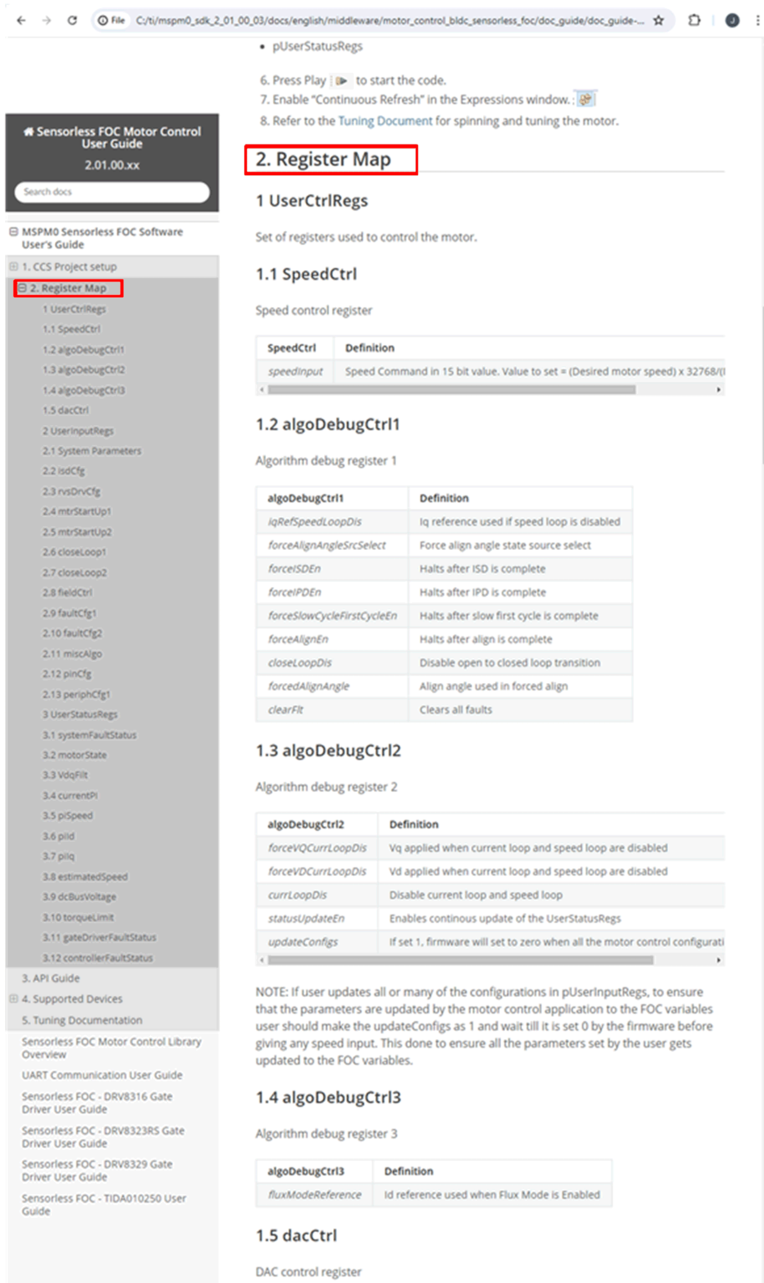


Figure 4-7. Register Map

Motor and control parameters are found in `ISR.c`, which can be updated per the motor and system of the user. The parameters for motor EMJ_04APB22, unit of each parameter are shown below. For more information, see the *MSPM0 Sensorless FOC Tuning Guide* application note.

```
pUserInputRegs->systemParams.mtrResist = 2627; // Rs(mR)
pUserInputRegs->systemParams.mtrInductance = 8608; // Ls(uH)
pUserInputRegs->systemParams.mtrBemfConst = 3779; // 10*BEMP, BEMF(mVpHz)
pUserInputRegs->systemParams.voltageBase = 258.6; // Vbase(V)/sqrt(3)
pUserInputRegs->systemParams.currentBase = 8.25; // Ibase(A)
pUserInputRegs->systemParams.maxMotorSpeed = 200; // Maximum Speed(Hz)
pUserInputRegs->systemParams.speedLoopKp = 0.0539; // Speed Loop Kp
pUserInputRegs->systemParams.speedLoopKi = 0.036; // Speed Loop Ki
pUserInputRegs->systemParams.currLoopKp = 3.42; // Current Loop Kp
pUserInputRegs->systemParams.currLoopKi = 3678; // Current Loop Ki
```

After update motor and control parameters, click the *Compile* button, no error information and the `.out` file are created in the *Console* window, see Figure 4-8.

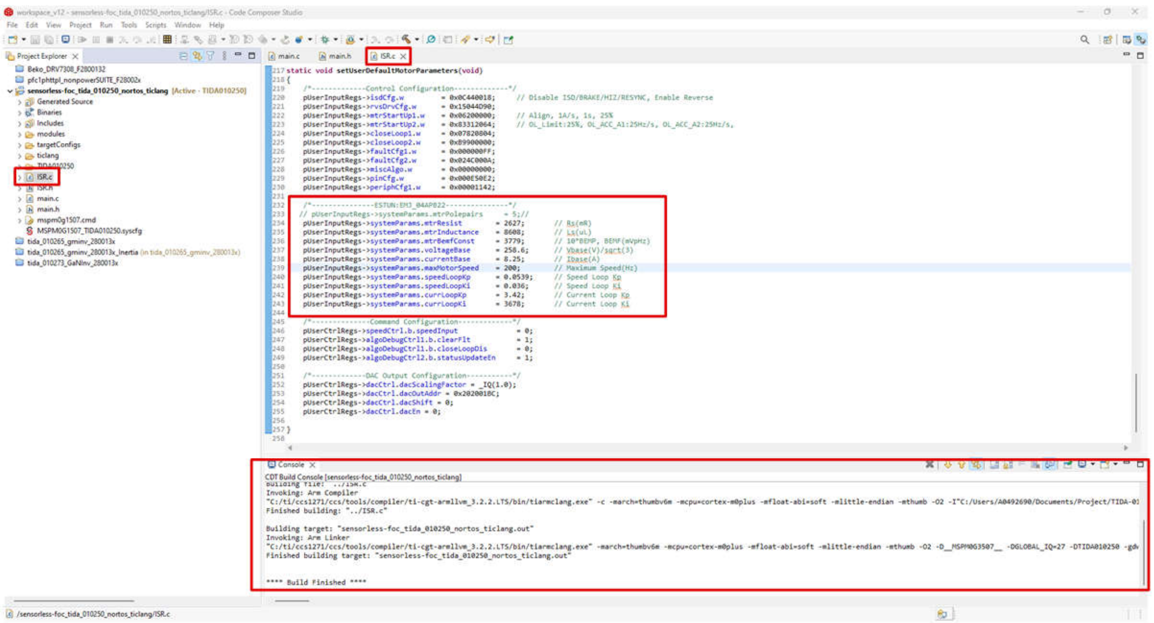


Figure 4-8. EMJ_04APB22 Motor Parameters and Compile Results

4.2.1.4 Download Image and Spin Motor

Click the *Run* → *Debug* menu options to download and debug software in CCS, then add `pUserCtrlRegs` variables into *Expressions* windows, Select *pUserCtrlRegs* → *speedCtrl* → *b* → *speedInput*, right click, select *Q-Values* → *Q-Value(15)*. Figure 4-9 shows where and how to change value type.

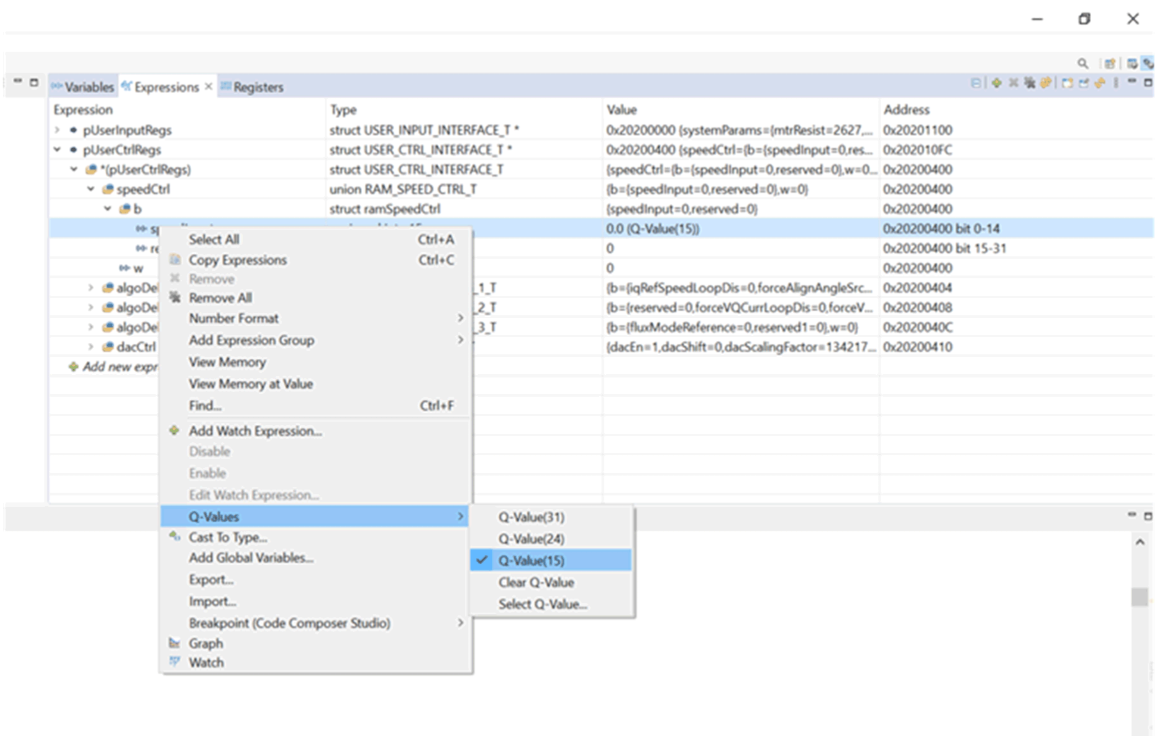


Figure 4-9. Download And Debug

Run code by clicking the *Run* button in CCS, and change the `speedInput` to a non-zero value to spin the motor, for example, 0.6, this number is a normalization number of the maximum speed, so if `speedInput` = 1, the motor runs at the maximum speed. To stop the motor, set `speedInput` to zero.

Figure 4-10 shows where to change the `speedInput` value.

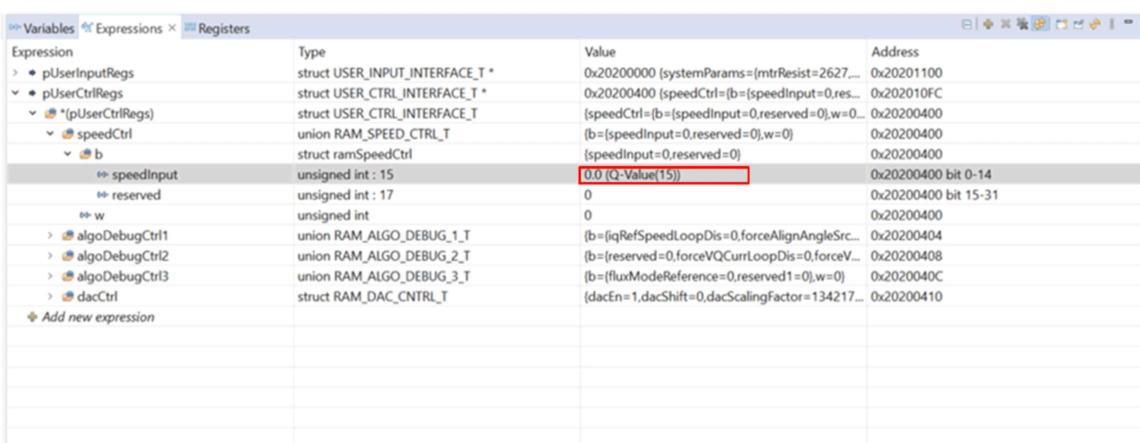


Figure 4-10. Set Motor Speed Percentage by `speedInput`

4.3 Test Results

The following sections show the test data. The test results are divided into multiple sections that cover the steady state performance and data, functional performance waveforms, and transient performance waveforms of a PMSM motor.

4.3.1 Test Setup

Figure 4-2 shows the position of these blocks and the connectors on the board. Use the following steps to set up the test.

1. Connect a serial wire debug (SWD) emulator to connector J8 to debug or program the MSPM01507. Isolate the host PC from TIDA-010250 board.
2. Connect a motor cable to the terminals J4, J5, and J6.
3. Apply a DC bus power, AC power supply or AC mains power to the inverter by connecting the power to J1, J2, and J3.
    - The maximum output of the DC power supply is 380VDC.
    - The maximum output of the AC power supply is 265VAC, 50/60Hz.
    - AC main power is 220VAC, 50/60Hz.

4.3.2 Auxiliary Power Supply Test

Figure 4-11 shows the buck power supply waveforms with 200mA load at $15V_{DC}$ output.

- CH1 (Blue): 15V voltage rail
- CH3 (Purple): switching node at pin 1 of UCC28881
- CH4 (Green): 15V output current

Figure 4-12 shows the buck inductor temperature at 15V, 100mA at 25°C ambient temperature.

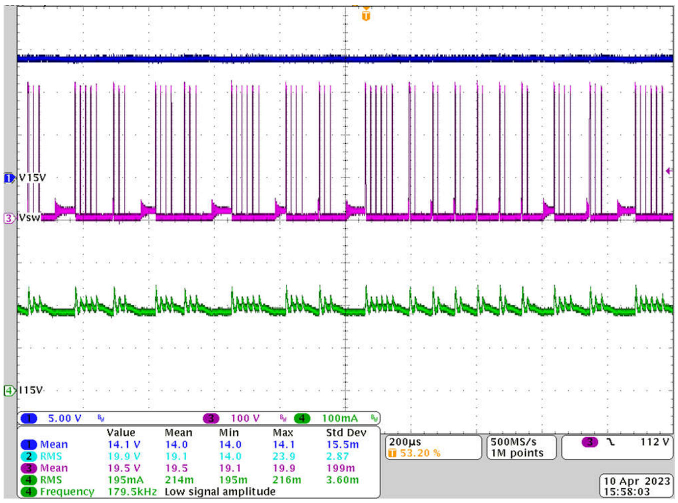


Figure 4-11. UCC28881 Waveform at $220V_{AC}$, 200mA

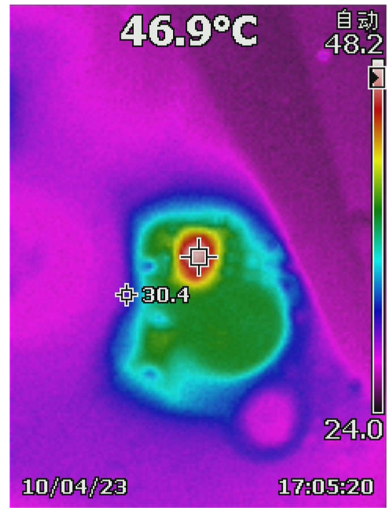


Figure 4-12. Inductor Temperature Rising of Buck Supply at $220V_{AC}$, 100mA

4.3.3 Current Open Loop Test

This test shows software behavior to generate a sinusoidal phase current under open loop mode, Figure 4-13 shows the waveform.

- CH2 (Cyan): AC input voltage
- CH3 (Purple): DC bus voltage
- CH4 (Green): Current of phase U

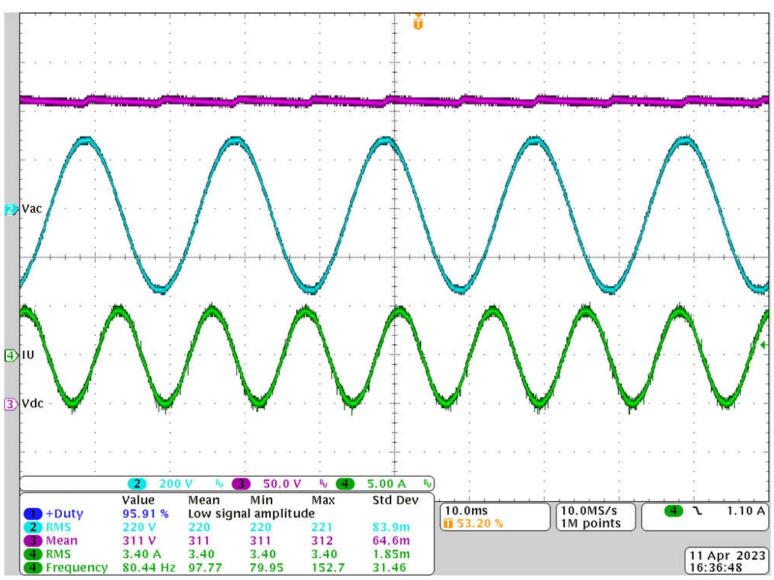


Figure 4-13. Phase Current at Open Loop Mode

4.3.4 Overcurrent Protection Test

This test can be done with an external $15V_{DC}$ power supply. Use the following steps for this test:

1. Power on the board with an external 15VDC power supply from DC Jack J7
2. Connect a DC power supply to two terminals of shunt resistor R67
3. Set the DC power supply at constant voltage mode, and maximum current
4. Enable output, then a surge output current flows through R67.
5. Adjust the power supply voltage and current output
6. Make sure the surge current is high enough (> 6.5ADC) to trigger OCP.

Figure 4-14 shows the FAULT signal falls once current is over 6A. The falling time is less than 2μs, which can be fast enough to protect most of IGBT.

- CH1 (Blue): Fault signal at test point of #FAULT
- CH4 (Green): Current on R67

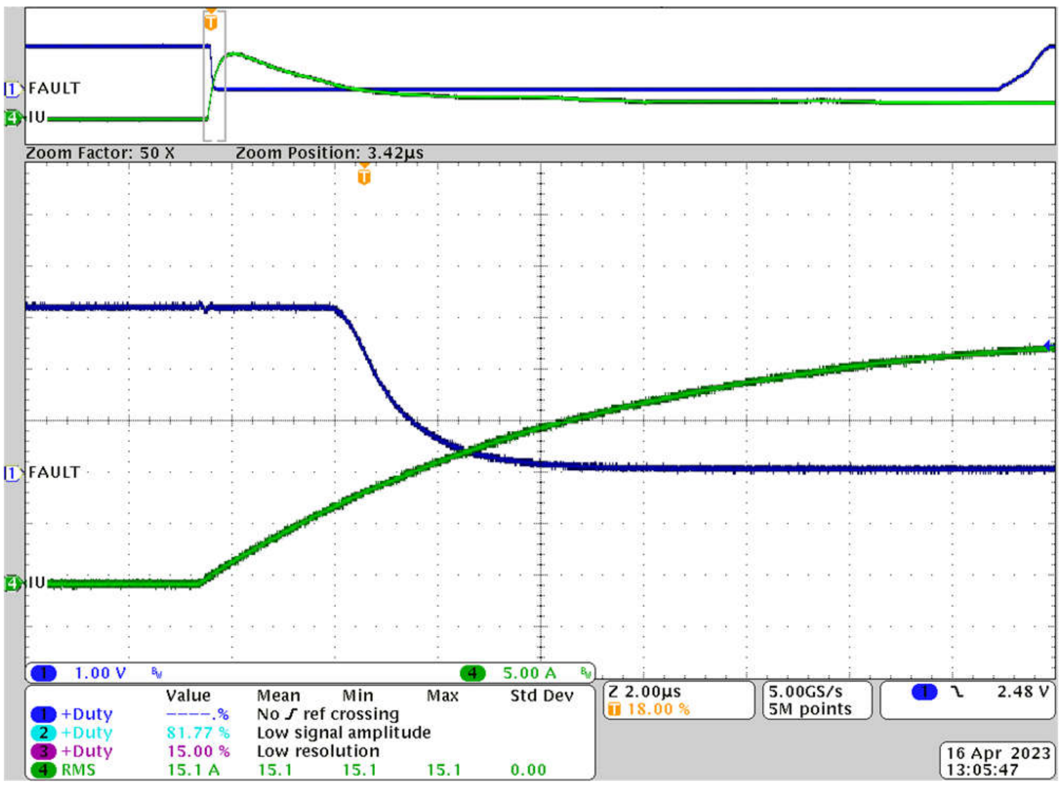


Figure 4-14. Overcurrent Protection Response Time

4.3.5 Motor Start-Up Sequence

Figure 4-15 shows the start-up sequence waveform for a PMSM motor with a sensorless FOC algorithm. The sequence usually consists of three phases: align, open loop ramp-up, speed closed loop. Complete the following steps during aligning:

1. Slowly increase aligning current to prevent any surge current
2. Move to open loop ramp-up
3. Ramp-up current can be set to meet the start load requirement
4. The rotor position observer starts to work during ramp-up time
5. Once the motor speed reaches the set point and the rotor angle error is small enough, then the software moves to closed speed and closed current loop

The following list of channels are presented in Figure 4-15.

- CH1(Blue): Observed rotor angle
- CH2 (Cyan): AC input voltage
- CH3 (Purple): DC bus voltage
- CH4 (Green): Current of phase U

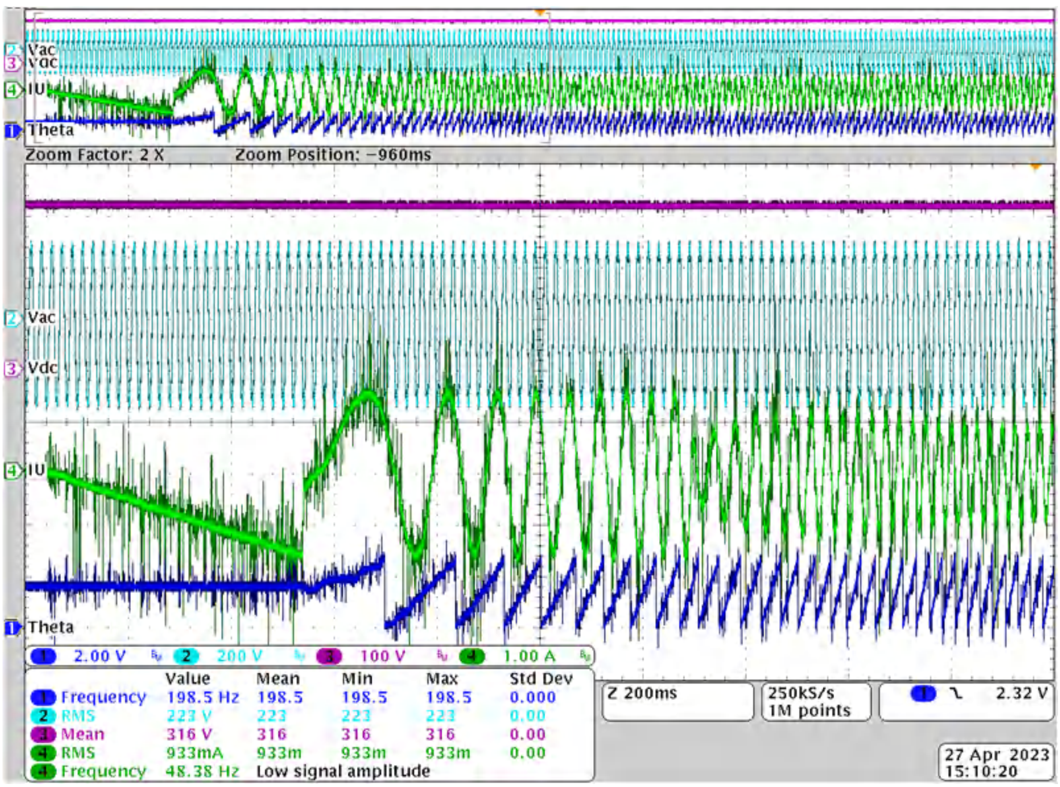


Figure 4-15. Motor Start-Up Sequence for PMSM With Senseless FOC Algorithm

4.3.6 Load Test

A load test was conducted to verify the overall thermal design. Figure 4-16 shows the board temperature rising with a 460W load. The heat sink temperature is only 32°C. Fuse and diode bridge are the hottest locations, but there is still enough margin, and the fuse cover can be removed to provide cooling.

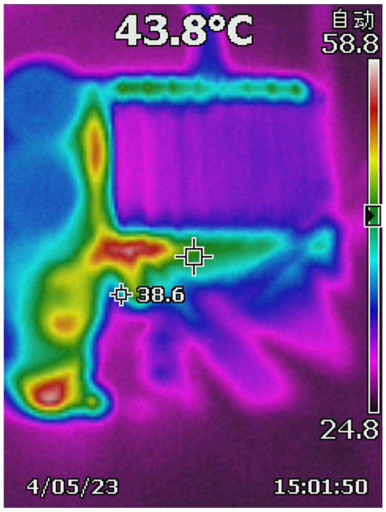


Figure 4-16. Board Temperature Rising With 460W Load

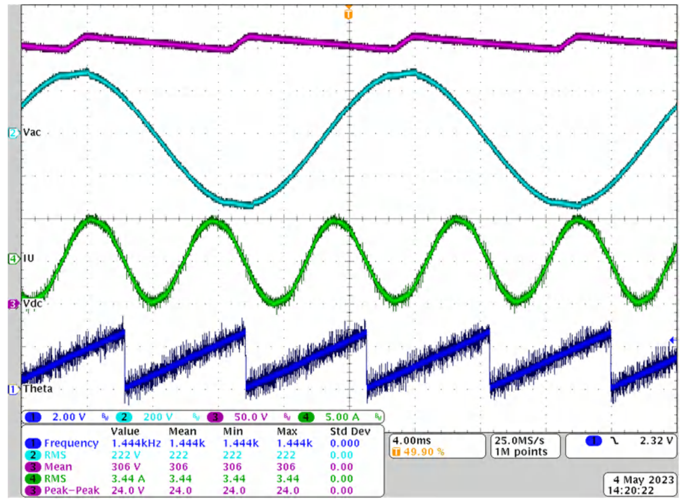


Figure 4-17. Test Waveform With 460W Load

Figure 4-17 shows the test waveform with a 460W load and the following channel assignments:

- CH1(Blue): Observed rotor angle
- CH2 (Cyan): AC input voltage
- CH3 (Purple): DC bus voltage
- CH4 (Green): Current of phase U

Figure 4-18 shows load test setup with a dynamometer.

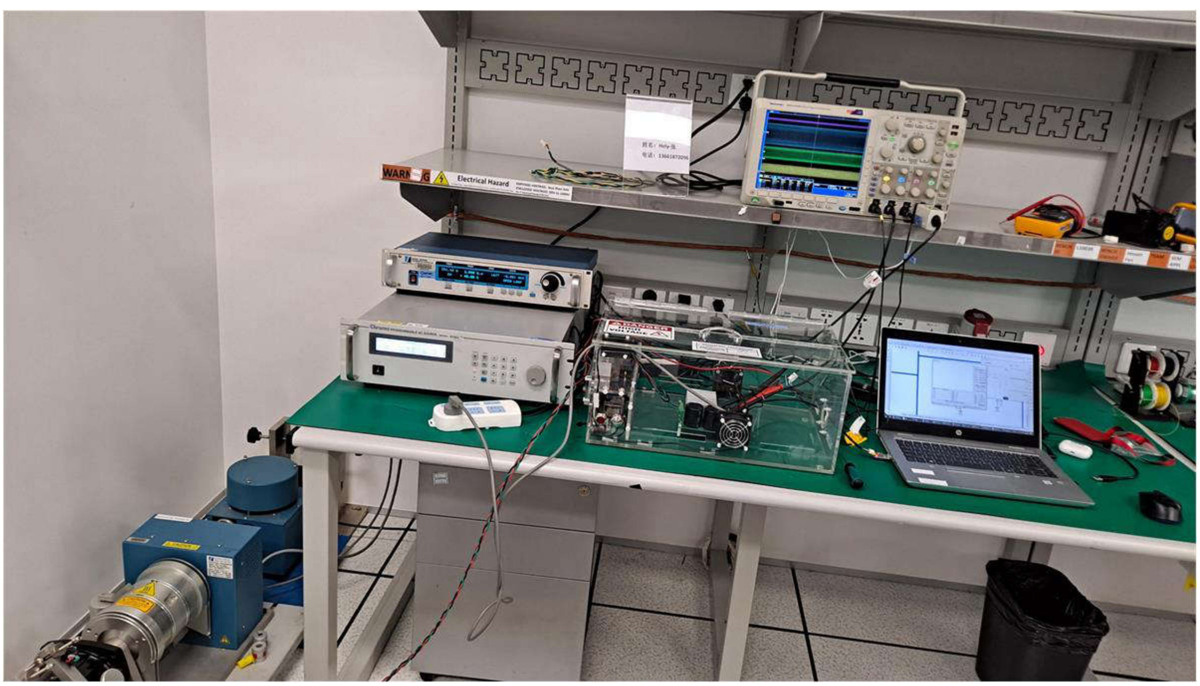


Figure 4-18. Load Test Setup

4.4 Migrate Firmware to a New Hardware Board

4.4.1 Configure the PWM, CMPSS, and ADC Modules

`SYSCFG_DL_init()` has initialization functions. Find `SYSCFG_DL_init()` in `main.c`, press *CTRL* and click the function, `SYSCFG_DL_init()` is opened, and functions to configure GPIO, ADC, PWM, and so forth can be found in `SYSCFG_DL_init()`. Figure 4-19 shows those functions.

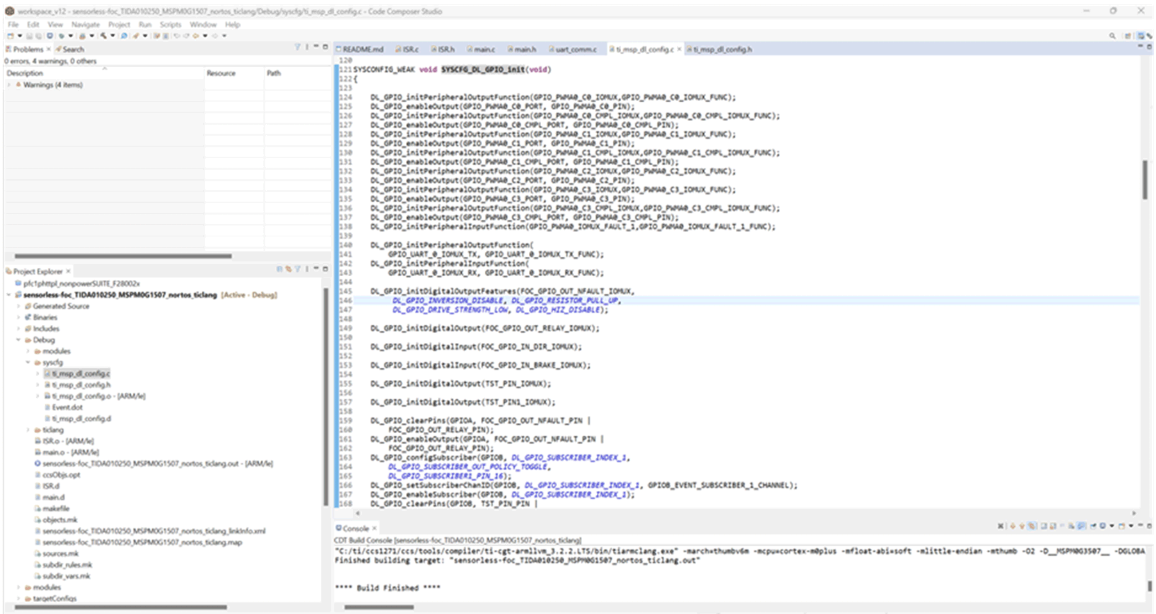


Figure 4-19. GPIO, ADC, and PWM Functions for Initialization

In *Debug → sysfcg → ti_msp_dl_config.h*, all defines for GPIO, PWM, and ADC can be found and updated for the new hardware board. Figure 4-20 shows those defines.

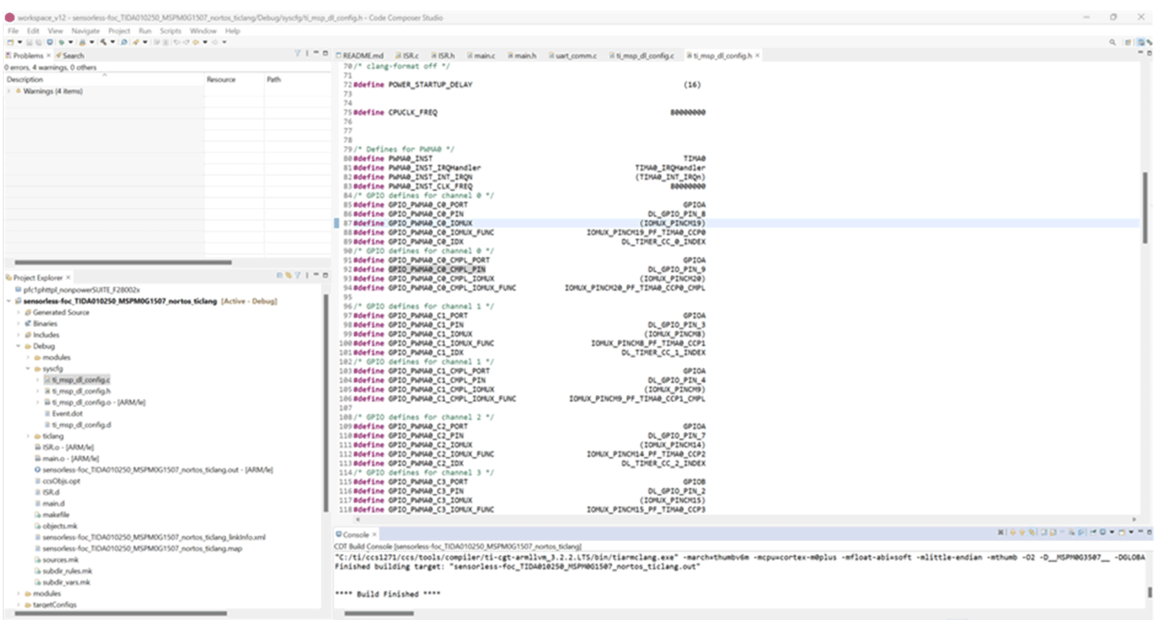


Figure 4-20. GPIO, ADC, and PWM Defines

4.4.2 Motor and Control Parameters Tuning

For more motor and control parameters tuning, see the *MSPM0 Sensorless FOC Tuning Guide* application note.

5 Design and Documentation Support

5.1 Design Files

5.1.1 Schematics

To download the schematics, see the design files at TIDA-010250.

5.1.2 BOM

To download the bill of materials (BOM), see the design files at TIDA-010250.

5.2 Tools

Tools

Code Composer Studio™	Code Composer Studio® (CCS) is an integrated development environment (IDE) for TI's microcontrollers and processors. CCS comprises a suite of tools used to develop and debug embedded applications. Code Composer Studio is available for download across Microsoft® Windows®, Linux® and macOS® desktops. CCS can also be used in the cloud by visiting the TI developer zone.
MSPM0-SDK	The MSPM0 SDK provides the ultimate collection of software, tools and documentation to accelerate the development of applications for the MSPM0 MCU platform under a single software package.

5.3 Documentation Support

1. Texas Instruments, *MSPM0G150x Mixed-Signal Microcontrollers Data Sheet*
2. Texas Instruments, *UCC28881 700-V, 225-mA Low Quiescent Current Off-Line Converter Data Sheet*
3. Texas Instruments, *UCC27712 620-V, 1.8-A, 2.8-A High-Side Low-Side Gate Driver with Interlock Data Sheet*
4. Texas Instruments, *TLV906xS 10-MHz, RRIO, CMOS Operational Amplifiers for Cost-Sensitive Systems Data Sheet*
5. Texas Instruments, *TPS54202 4.5-V to 28-V Input, 2-A Output, EMI Friendly Synchronous Step Down Converter Data Sheet*
6. Texas Instruments, *ISO672x General Purpose Basic Dual-Channel Digital Isolators with Robust EMC Data Sheet*

5.4 Support Resources

TI E2E™ support forums are an engineer's go-to source for fast, verified answers and design help — straight from the experts. Search existing answers or ask your own question to get the quick design help you need.

Linked content is provided "AS IS" by the respective contributors. They do not constitute TI specifications and do not necessarily reflect TI's views; see TI's Terms of Use.

5.5 Trademarks

6 About the Author

HELY ZHANG is a System Application Engineer at Texas Instruments, where he is responsible for developing home appliance related power delivery and motor inverters. Hely earned his masters degree from Anhui University of Science and Technology with Power electronics in 2002, and worked in SolarEdge and General Electric before joining TI.

7 Revision History

NOTE: Page numbers for previous revisions may differ from page numbers in the current version.

Changes from Revision A (April 2024) to Revision B (September 2024) **Page**

- Established *MSPM0G1507* as device used in this reference design.......... 1
- Added content to Section 4.2 12
- Added Section 4.4 22

Changes from Revision * (May 2023) to Revision A (April 2024) **Page**

- Replaced UCC54202 with TPS54202 in Section 2.2 4

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